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# THE AMERICAN DOG TICK, EASTERN CARRIER OF ROCKY MOUNTAIN SPOTTED FEVER

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## ECONOMIC IMPORTANCE

The wide distribution of Rocky Mountain spotted fever in the central and eastern portions of the United States, where the American dog tick, *Dermacentor variabilis* (Say), is the principal, if not the only, vector, has made necessary a more complete knowledge of that tick.

Since the discovery, a few years ago, that Rocky Mountain spotted fever is present in the Eastern States and that the American dog tick is the vector of the disease there, this tick has come to be regarded as of great economic importance. In 1911 Maver (*8*)[1] reported the experimental transmission of the western strain of the disease by *Dermacentor variabilis*. Early in 1931 Rumreich, Dyer, and Badger (*13*) identified Rocky Mountain spotted fever in the Eastern States and later in the same year (*3*) reported the experimental transmission of the eastern strain by the American dog tick. Badger (*1*), in 1932, collected naturally infected specimens on a farm in Virginia. A useful summary of the present knowledge of Rocky Mountain spotted fever has been published by Parker (*9*). The number of reported cases of Rocky Mountain spotted fever in the eastern and southern portions of this country averages about 140 per year, with a mortality of about 25 percent. The fear of a disease with such a high mortality rate extends the economic effect of the tick's presence beyond the mere incidence of the disease. This has tended to affect adversely the property values and the resort business in certain localities where ticks are abundant.

The American dog tick has also been associated with other diseases, including tularaemia. Green (*4*) demonstrated the natural occurrence of tularaemia infections in *Dermacentor variabilis* in 1931, and in 1934 Philip and Jellison (*11*) secured experimental transmission with

[1] Italic numbers in parentheses refer to Literature Cited, p. 25.

this species. Human cases attributed to tick bite have now been reported from several States. In 1932 Rees (*12*) reported the experimental transmission of anaplasmosis of cattle by means of the American dog tick. Parker et al. (*10*) have summarized the present knowledge of the relation of *D. variabilis* to disease transmission.

Aside from its disease-transmitting propensities, this tick is important because of the aversion people have to ticks crawling on the clothing and body. Considering the abundance of American dog ticks in many localities, the number of them that attach themselves to man is relatively small. Their attachment, however, frequently results in persistent itching and irritation at the point of attack.

As a pest of dogs *Dermacentor variabilis* ranks high. In heavily infested localities dogs that are allowed free run frequently pick up scores to hundreds of ticks each day. This causes severe irritation, bad disposition, and loss of condition. While no authentic cases of dogs dying from gross infestation have been observed by the writers, animals are known to have been destroyed becaused of weakened condition, ill temper, and unsightly appearance. Canine paralysis has also been attributed to the presence of numbers of ticks of this species.

Horses are often severely irritated by this tick. Attachment, particularly in well-groomed animals, usually takes place in the mane, tail, and fetlocks. Some horses thus infested keep rubbing, switching, and stamping almost constantly.

## DISTRIBUTION

The American dog tick is widely distributed throughout the United States east of the Rocky Mountains, in western and northern California, and in parts of Oregon. There is one record of its occurrence in Mexico, and doubtless it is present in that country some distance south of the border on both the east and west coasts. This species has been taken in Alaska; also in Labrador, Nova Scotia, Ontario, and Manitoba, Canada.

This tick is most abundant along the eastern coast from Massachusetts to Florida, especially within a few miles of the beach. It is rather abundant over much of Texas and Florida. It is also abundant in some inland localities, such as southern Iowa and parts of Wisconsin and Minnesota. The tick has been observed in greatest numbers on certain islands off the coast of Massachusetts and the coast of South Carolina. It is interesting to observe the distribution and abundance of ticks in the New England States. The south side of Cape Cod and the islands to the south—Martha's Vineyard, Nantucket, and Naushon—are very heavily infested. Ticks are less abundant on the north than the south side of the cape, and there are few if any to be found north of Plymouth, or inland beyond Middleboro and Taunton, Mass. Along the coast there is a marked diminution in numbers from Marion, Mass., westward. They are reported to be rather numerous on islands in Narragansett Bay. A few are present on the west side of that bay and as far west as Stonington, Conn. This species is rather abundant on Long Island, especially on its eastern half. In Maryland the tick is abundant along the Chesapeake Bay and is rarely seen west of the Blue Ridge.

It appears likely that in the Eastern States low relative humidity is the most important factor in limiting distribution and abundance of this species.

The ticks are most numerous in areas covered with grass or underbrush, occurring less frequently in forests, where the species of mice that serve as hosts of the immature stages are less numerous.

The distribution, based on records collected by the Bureau of Entomology and Plant Quarantine, is shown in figure 1.

## HOSTS

The dog is the preferred host of the adult ticks. A number of other animals of the larger species also serve as hosts for the adults. On the other hand, the immature stages (larvae and nymphs) engorge almost exclusively on small rodents such as mice (fig. 2). Apparently

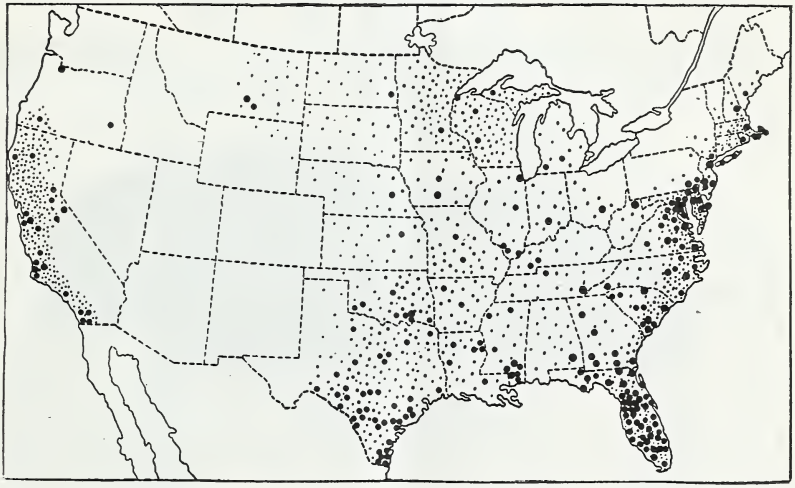

FIGURE 1.—Distribution of *Dermacentor variabilis* in the United States. Large dots indicate localities where collections were made by the Bureau of Entomology and Plant Quarantine; small dots indicate the probable range.

rabbits are of very little importance as hosts for this tick, and birds do not serve as hosts.

The relative frequency with which the adults of this tick are taken on different hosts is indicated by the following figures from the accession records of the Division of Insects Affecting Man and Animals of the Bureau of Entomology and Plant Quarantine: On dog, 218; man, 57; cattle, 31; coyote, 26; opossum, 18; hog, 18; horse, 16; racoon, 10; wildcat, 10; squirrel, 9; sheep, 7; badger, 6; wolf, 4; skunk, 4; deer, 3; fox, 3; cat, 2; peccary, 2; weasel, 2; ass, 1; leopard cat, 1; mountain lion, 1; Mexican lion, 1; mule, 1; rabbit, 1.

The following is a list of the collections of immature stages contained in the accession catalog, with the number of times larvae and nymphs, respectively, have been taken on the different hosts: White-footed mice (*Peromyscus*)—larvae 68, nymphs 18; meadow mice (*Microtus*)—12, 13; pine mice (*Pitymys*)—4, 8; house mouse (*Mus musculus*)—3, 0; kangaroo mouse (*Zapus*)—1, 1; mouse, species in doubt—5, 5; cottontail rabbit—3, 8; swamp rabbit—2, 1; cotton rat

(*Sigmodon hispidus*)—3, 1; Norway rat—2, 1; wood rat (*Neotoma*)—0, 1; squirrels—0, 7; cat—0, 2; shrew (*Blarina brevicauda*)—2, 1; sheep—0, 1 (unengorged); cattle—0, 1 (engorged); mole (*Scalopus aquaticus machrinus*)—1 (unengorged), 0.

While no collections have been made of nymphs or larvae attached to man, and such occurrences are certainly unusual, statements of residents on islands south of Cape Cod indicate that nymphs occasionally attach to man.

In localities where rats are abundant and live to a large extent in the open they are of some importance as hosts for larvae and nymphs.

Collections of mice in nature show that ground-surface-inhabiting species, such as the meadow mice (*Microtus*), are most important as hosts for both larvae and nymphs. Species that climb, such as white-footed mice (*Peromyscus*), are much less important. Furthermore, the numerical abundance of *Microtus* is such as to make this

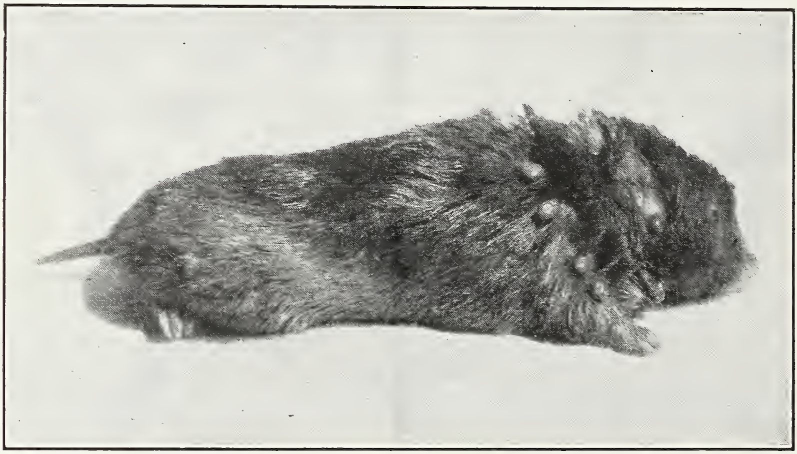

FIGURE 2.—A pine mouse with well-engorged nymphs of *Dermacentor variabilis* attached around the head. Four-fifths natural size.

group of mice of far greater importance as a host than any other. Even in laboratory tests the meadow mice prove in most cases to be the best hosts for larvae. In these tests from 400 to 2,500 larvae were put in a glass jar with a single mouse. The average number of larvae becoming engorged on the three species of mice was, meadow mouse 409, pine mouse 261, white-footed mouse 131. These three kinds of mice ranked in the same order as hosts for nymphs. Ticks have occasionally been found on house mice collected in fields, but have not been taken on the mice caught in houses. In the laboratory they seem to be slightly inferior to the white-footed mouse as a host. More than 100 larvae were found on a single meadow mouse (*Microtus pennsylvanicus pennsylvanicus*) caught in nature, at Fairfax, Va., on January 27, 1934.

Experience with the use of mice for the engorgement of ticks in the laboratory shows that when first captured they are better hosts than after they have been infested several times. This resistance to infestation apparently is due to the animals becoming more aware of the presence of the ticks and more active in trying to scratch them off.

## LIFE HISTORY

Like other ticks of this family, *Dermacentor variabilis* passes through four stages, the egg, the larva or seed tick, the nymph, and the adult. The life history was worked out in some detail by Hooker, Bishopp, and Wood (*6*) in 1912, and a few observations were given by Hadwen (*5*) in 1913. In 1926 Zebrowski (*15*) published a report on the morphology of the species, and Cooley (*2*) briefly summarized the life history in 1932. The report of the Chief of the Bureau of Entomology for

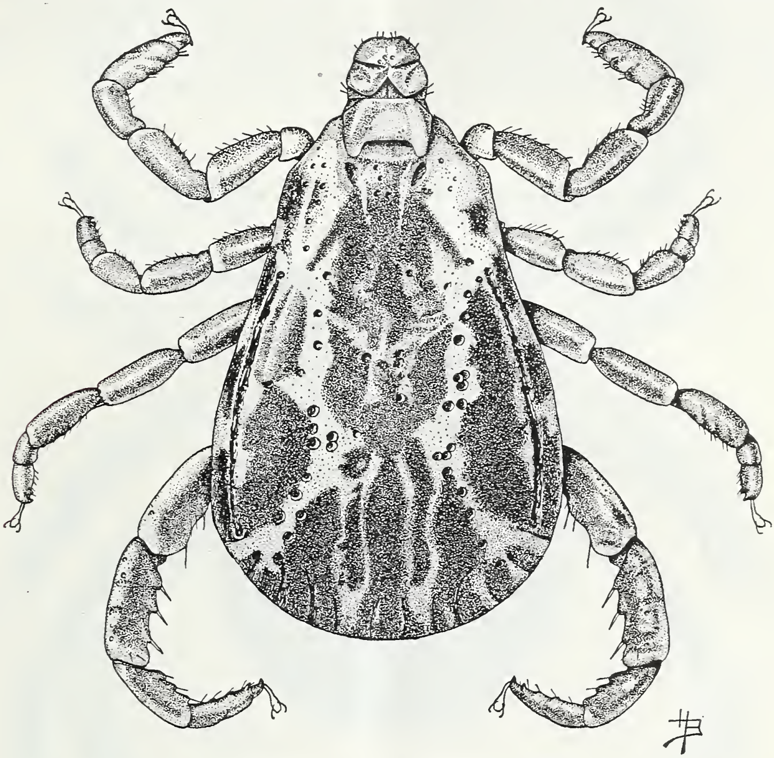

FIGURE 3.—Dorsal aspect of male *Dermacentor variabilis*. × 17.

1933 (*14*) discussed the host relationships, recording meadow mice, pine mice, and white-footed mice as the principal hosts of the immature stages in the East.

### ADULT

The adult (male and female) is the only stage ordinarily seen. It is the common "wood tick" of the Central and Eastern States. It is often observed crawling on the clothing after one has been walking in the country and is commonly observed on dogs. The male (figs. 3 and 4) has a hard brown covering over the back which is marked with white lines. The female (figs. 5 and 6) is brown and bears a hard shield marked with white on the back at the head end. When unfed the males and females are about three-sixteenths inch in length. The bodies of the females when engorged (fig. 7) are bluish gray and are about three-eighths inch in width by one-half inch in length. The males do not increase greatly in size upon feeding.

### ADULT LONGEVITY

The unengorged adults are very long-lived if kept under favorable conditions. In one lot of one male and three females that molted to adults on September 6, 1933, kept in a shady, moist place in Maryland near the District of Columbia, one female was still alive on May 21, 1936, and all were dead on July 25, 1936, a longevity of at least 988 days (2 years and 8.6 months) and possibly as long as 1,053 days. Another lot that molted to adults between April 27 and May 2, 1934, kept under similar conditions, lived between 755 and 819 days.

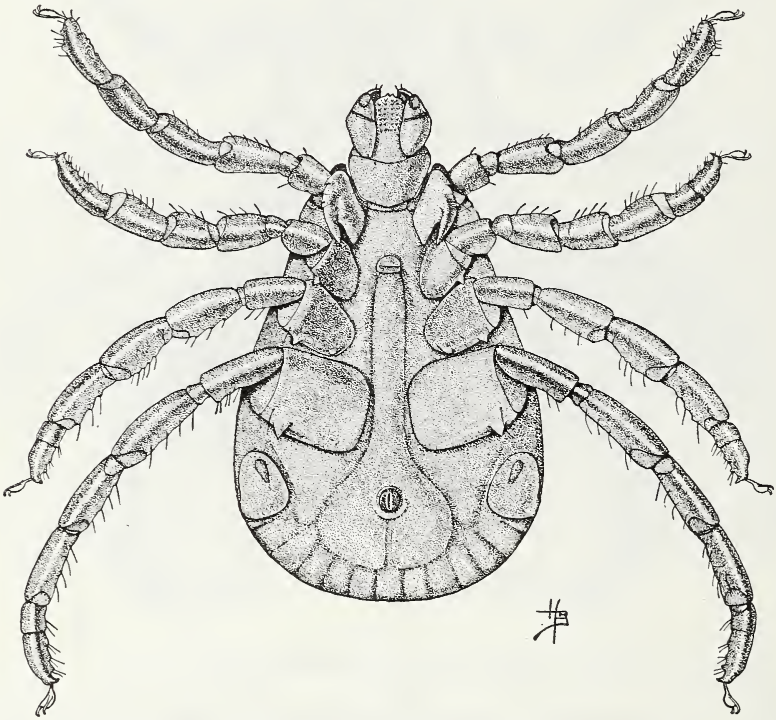

FIGURE 4.—Ventral aspect of male *Dermacentor variabilis*. × 18.

In the laboratory, probably owing to higher temperatures, longevity was not quite so great. One lot of eight males and eight females that molted from nymphs on April 6, 1934, lived for a period of between 929 and 986 days. One other lot lived for over 910 days, three lots between 850 and 880 days, two lots lived over 820 days, and two lots lived more than 700 days. Longevity in other lots ranged from 162 to 657 days.

The adults as well as other stages require considerable moisture. If kept under dry conditions, longevity is greatly reduced. In spring the adults are often found to be rather widely scattered over areas where favorable hosts abound. As the summer advances they are observed to be concentrated in the lower bushy areas. There is some evidence that they move toward the moist, protected places, though it is likely that the localized distribution in midsummer is largely due to the death of the individuals in the drier, less favorable locations.

The longevity of adults which have attached to hosts is comparatively short. Most of the males and slightly engorged females which

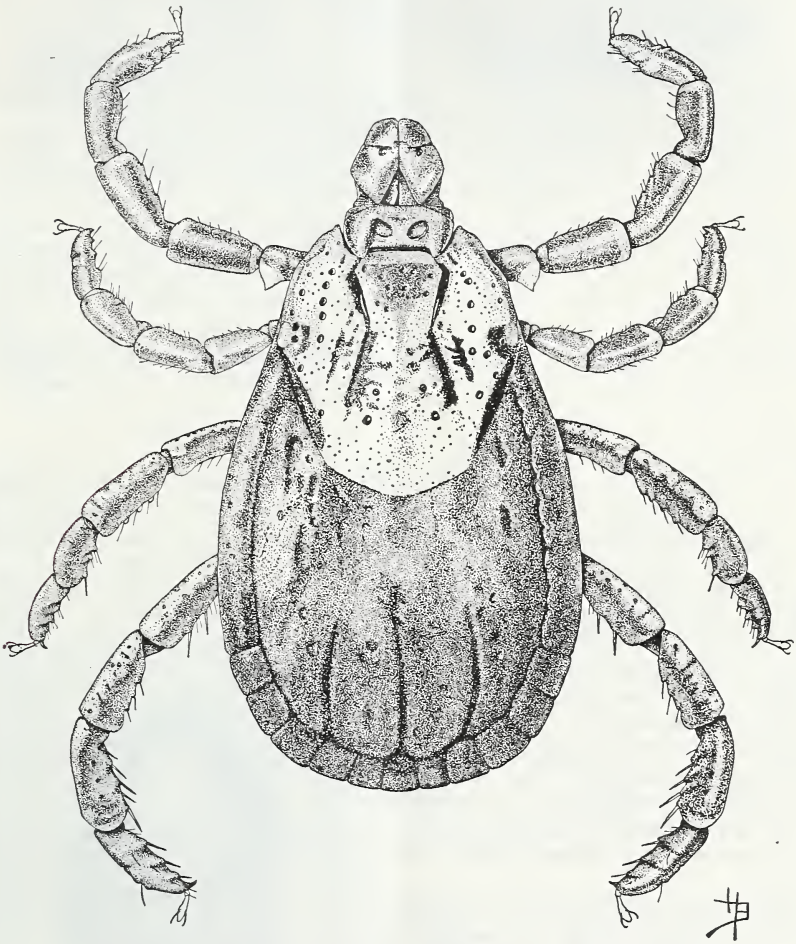

FIGURE 5.—Dorsal aspect of unengorged female *Dermacentor variabilis*. × 17.

are removed from a host die within a few weeks, though an occasional one may live for 5 or 6 months.

This is a matter of some economic importance because of the greater danger to man from the bite of an adult tick that has previously fed, since the organism causing Rocky Mountain spotted fever is activated in the tick by feeding, and such a partially fed tick attaching for a very short time may infect a person.

ENGORGEMENT AND MATING

The engorgement of females requires from 5 to 13 days. It is more difficult to get adults to attach late in the summer and in the fall than in the spring and early in the summer, and engorgement is usually slower. This is in accord with the reduced activity of adults in nature as the season advances.

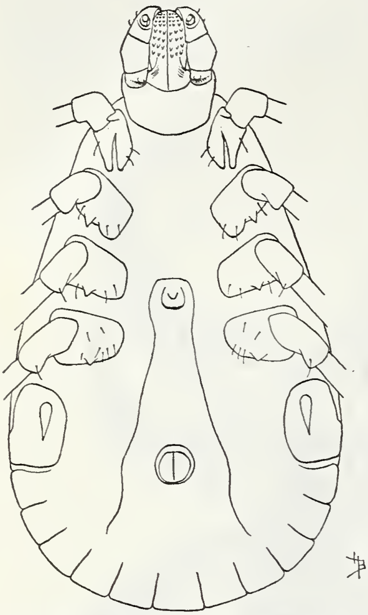

FIGURE 6.—Ventral aspect of unengorged female *Dermacentor variabilis*. × 18.

Mating takes place on the host from 4 to 6 days after attachment, but is always preceded by a feeding period for both males and females.

Engorgement of females is retarded by the absence of males. In one instance two females were put on a host without males. One of these remained attached for 6 days without perceptible engorgement, the other became slightly engorged during a period of 21 days. At the end of that period two males were applied, and after mating engorgement was immediately accelerated.

OVIPOSITION

The preoviposition period varies with the temperature, ranging from 3 to 24 days, and the oviposition period ranges from 14 to 32 days.

The ovoid brownish eggs are laid in large masses (fig. 8) in protected places on the ground. Maximum daily egg production is reached a few days after oviposition begins, and there is usually a marked decline in the oviposition rate during the last 10 to 15 days. The largest number of eggs deposited in 1 day was 800. The number of eggs deposited by a female usually ranges from 4,000 to 6,500; the maximum number noted was 6,941.

FIGURE 7.—Engorged female *Dermacentor variabilis*. × 3.

Engorged females died in from 3 to 36 days after oviposition was completed. The total longevity of such individuals after dropping (leaving the host after becoming engorged) ranges from 25 to 58 days.

Some typical records on the preoviposition, incubation, and larval longevity are given in table 1. Daily oviposition records are given in table 2.

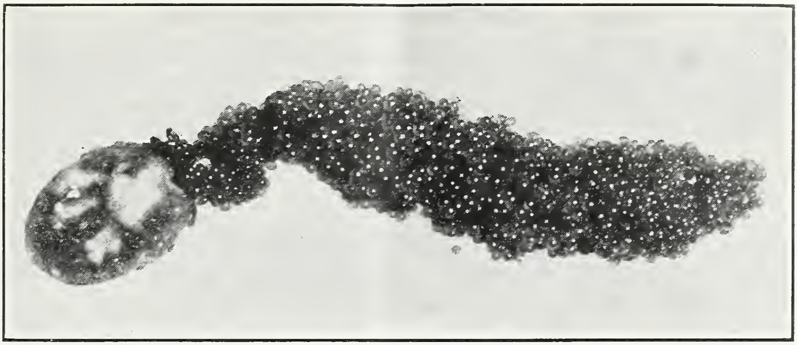

FIGURE 8.—Female *Dermacentor variabilis* and egg mass. × 2.

TABLE 1.—*Preoviposition, incubation, and larval longevity of Dermacentor variabilis*

| Date female dropped or was picked off | Host | Date oviposition began | Preoviposition period | Date hatching began | Incubation period | Date larvae were last noted alive | Date all larvae were noted dead | Larval longevity |
|---|---|---|---|---|---|---|---|---|
| *1932* | | *1932* | *Days* | *1932* | *Days* | *1933* | *1933* | *Days* |
| June 17 | Dog | June 22 | 5 | July 21 | 29 | Feb. 21 | Mar. 13 | 215–235 |
| | | | | | | *1932* | *1932* | |
| July 24 | do | July 30 | 6 | Aug. 26 | 27 | Nov. 21 | Nov. 28 | 87–94 |
| *1933* | | *1933* | | *1933* | | *1934* | *1934* | |
| Apr. 28 | do | May 5 | 7 | June 11–13 | 37–39 | Apr. 23[1] | | 314 |
| Apr. 29 | do | May 12 | 13 | June 16–17 | 35–36 | May 28 | June 28 | 345–377 |
| May 10 | do | May 17 | 7 | June 22 | 36 | do | do | 340–371 |
| Do | do | May 20 | 10 | June 23 | 34 | do | do | 339–370 |
| June 11 | do | June 21 | 10 | July 21 | 30 | do | do | 311–342 |
| July 8 | Horse | July 16–17 | 8–9 | Aug. 13–14 | 27–29 | June 28[1] | | 318 |
| July 13 | Dog | July 20 | 7 | Aug. 15 | 26 | May 7 | May 28 | 265–286 |
| Aug. 13 | do | Aug. 19 | 6 | Sept. 21 | 33 | do | do | 228–249 |
| Do | do | Aug. 18 | 5 | Sept. 18 | 31 | May 28 | June 28 | 252–283 |
| *1934* | | *1934* | | *1934* | | *1935* | *1935* | |
| May 12 | do | June 5 | 24 | July 5 | 30 | Apr. 16 | May 20 | 285–319 |
| May 24 | do | June 4 | 11 | June 30–July 2 | 26–28 | do | do | 288–324 |
| June 2 | do | June 10 | 8 | July 6 | 26 | May 20 | June 28 | 318–357 |
| Do | do | do | 8 | July 7 | 27 | Apr. 16 | May 20 | 283–317 |
| Do | do | June 11 | 9 | July 8 | 27 | May 20 | June 28 | 316–355 |
| | | | | | | *1934* | | |
| June 8 | Horse | June 14 | 6 | July 13 | 29 | Dec. 11 | Jan. 24 | 151–195 |
| | | | | | | *1935* | | |
| July 15 | Dog | July 20 | 5 | Aug. 17 | 28 | Apr. 16 | May 20 | 242–276 |
| July 18 | Guinea pig | July 23 | 5 | Aug. 19 | 27 | May 20 | June 28 | 274–313 |
| July 19 | do | do | 4 | Aug. 20 | 28 | Mar. 12 | Apr. 16 | 204–239 |
| Do | do | July 24 | 5 | do | 27 | Apr. 16 | May 20 | 239–273 |
| July 21 | do | July 25 | 4 | Aug. 23 | 29 | May 20 | June 28 | 270–309 |
| July 23 | do | July 26 | 3 | Aug. 25 | 30 | do | do | 268–307 |
| Aug. 5–6 | do | Aug. 12 | 6–7 | Sept. 14 | 33 | June 26[1] | | 285 |
| Aug. 7 | do | do | 5 | Sept. 16 | 35 | May 20 | June 28 | 246–285 |
| Aug. 8 | do | do | 4 | do | 35 | June 28 | Aug. 14 | 285–332 |
| Do | do | do | 4 | Sept. 17 | 36 | Apr. 16 | May 20 | 211–245 |
| Aug. 9 | do | Aug. 13 | 4 | Sept. 19 | 37 | May 20 | June 28 | 243–282 |

[1] Larvae applied to host on this date and became engorged; therefore maximum longevity cannot be given.

TABLE 2.—*Oviposition by Dermacentor variabilis*

| Date dropped or picked | Date first eggs deposited | Preoviposition period | Eggs deposited on the specified day after the female dropped engorged: 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | 13th | 14th | 15th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | *1933* | | | | | | | | | | | | |
| May 2 | May 15 | 13 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 236 | 247 | 292 |
| 4 | May 18 | 14 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 126 | 152 |
| *1934* | *1934* | | | | | | | | | | | | |
| Aug. 6 | Aug. 11 | 5 | 45 | 445 | 554 | 265 | 375 | 589 | 360 | 357 | 388 | 542 | 405 |
| 6 | ---do----- | 5 | 46 | 481 | 635 | 498 | 639 | 683 | 558 | 336 | 389 | 383 | 388 |
| 6 | ---do----- | 5 | 399 | 752 | 621 | 429 | 676 | 595 | 496 | 190 | 479 | 293 | 373 |
| *1909* | *1909* | | | | | | | | | | | | |
| Aug. 10 | Aug. 17 | 7 | ------ | ------ | 336 | 616 | 800 | 560 | 464 | 489 | 422 | 486 | 294 |
| *1911* | *1911* | | | | | | | | | | | | |
| May 22 | May 28 | 6 | ------ | 600 | 246 | 324 | 722 | 370 | 498 | 522 | 487 | 452 | 382 |
| 22 | May 30 | 8 | ------ | ------ | ------ | 239 | 653 | 379 | 413 | 457 | 528 | 335 | 278 |

| Date dropped or picked | Date first eggs deposited | Preoviposition period | Eggs deposited on the specified day after the female dropped engorged: 16th | 17th | 18th | 19th | 20th | 21st | 22d | 23d | 24th | 25th | 26th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | *1933* | | | | | | | | | | | | |
| May 2 | May 15 | 13 | 148 | 183 | 231 | ------ | 845 | 400 | 391 | 557 | 368 | 446 | ------ |
| 4 | May 18 | 14 | 57 | ------ | 880 | 408 | 468 | 623 | 512 | 555 | ------ | 576 | 169 |
| *1934* | *1934* | | | | | | | | | | | | |
| Aug. 6 | Aug. 11 | 5 | 288 | 423 | 466 | 265 | 256 | 83 | 111 | 89 | 28 | 28 | 26 |
| 6 | ---do----- | 5 | 193 | 261 | 304 | 229 | 227 | 97 | 125 | 78 | 61 | 59 | 0 |
| 6 | ---do----- | 5 | 140 | 110 | 140 | 64 | 39 | 18 | 28 | 17 | 14 | 16 | 0 |
| *1909* | *1909* | | | | | | | | | | | | |
| Aug. 10 | Aug. 17 | 7 | 418 | 391 | 373 | 356 | 195 | 200 | 131 | 99 | 87 | 41 | ------ |
| *1911* | *1911* | | | | | | | | | | | | |
| May 22 | May 28 | 6 | 214 | 252 | 165 | 131 | 58 | 20 | ------ | ------ | ------ | ------ | ------ |
| 22 | May 30 | 8 | 218 | 211 | 159 | 174 | 107 | 86 | 57 | 38 | ------ | ------ | ------ |

| Date dropped or picked | Date first eggs deposited | Preoviposition period | Eggs deposited on the specified day after the female dropped engorged: 27th | 28th | 29th | 30th | 31st | 32d | 33d | 34th | 35th | 36th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | *1933* | | | | | | | | | | | |
| May 2 | May 15 | 13 | 666 | 234 | 198 | 170 | 92 | 69 | ------ | 164 | 42 | 63 |
| 4 | May 18 | 14 | 0 | 5 | 47 | 226 | ------ | 399 | 49 | 60 | 35 | 27 |
| *1934* | *1934* | | | | | | | | | | | |
| Aug. 6 | Aug. 11 | 5 | 31 | 35 | 32 | 16 | 14 | 11 | 8 | 3 | 7 | 11 |
| 6 | ---do----- | 5 | 62 | 56 | 57 | 30 | 17 | 24 | 8 | 13 | 4 | ------ |
| 6 | ---do----- | 5 | 0 | 16 | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1909* | *1909* | | | | | | | | | | | |
| Aug. 10 | Aug. 17 | 7 | 72 | 12 | 9 | 4 | ------ | ------ | ------ | ------ | ------ | ------ |
| *1911* | *1911* | | | | | | | | | | | |
| May 22 | May 28 | 6 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 22 | May 30 | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

| Date dropped or picked | Date first eggs deposited | Preoviposition period | Eggs deposited on the specified day after the female dropped engorged: 37th | 38th | 39th | 40th | 41st | 42d | 43d | 44th | 45th | 46th | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | *1933* | | | | | | | | | | | | |
| May 2 | May 15 | 13 | 46 | 39 | 23 | ------ | 6 | ------ | ------ | ------ | ------ | ------ | 6,156 |
| 4 | May 18 | 14 | 25 | ------ | 36 | 9 | 6 | 0 | 0 | 7 | ------ | 3 | 5,460 |
| *1934* | *1934* | | | | | | | | | | | | |
| Aug. 6 | Aug. 11 | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 6,556 |
| 6 | ---do----- | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 6,941 |
| 6 | ---do----- | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 5,910 |
| *1909* | *1909* | | | | | | | | | | | | |
| Aug. 10 | Aug. 17 | 7 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 6,855 |
| *1911* | *1911* | | | | | | | | | | | | |
| May 22 | May 28 | 6 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 5,443 |
| 22 | May 30 | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 4,332 |

### LARVA OR SEED TICK

The larva (figs. 9 and 10) is about 0.6 mm long. It differs from the other stages in having only three pairs of legs. In unfed individuals the color is pale yellow, with brick-red markings on the sides of the shield. Engorged specimens are slate gray.

#### LARVAL LONGEVITY

The larvae prefer moist shady places, and when exposed to dry conditions they die in a relatively short time. They tolerate much moisture, and during cool weather masses of them, largely covered by

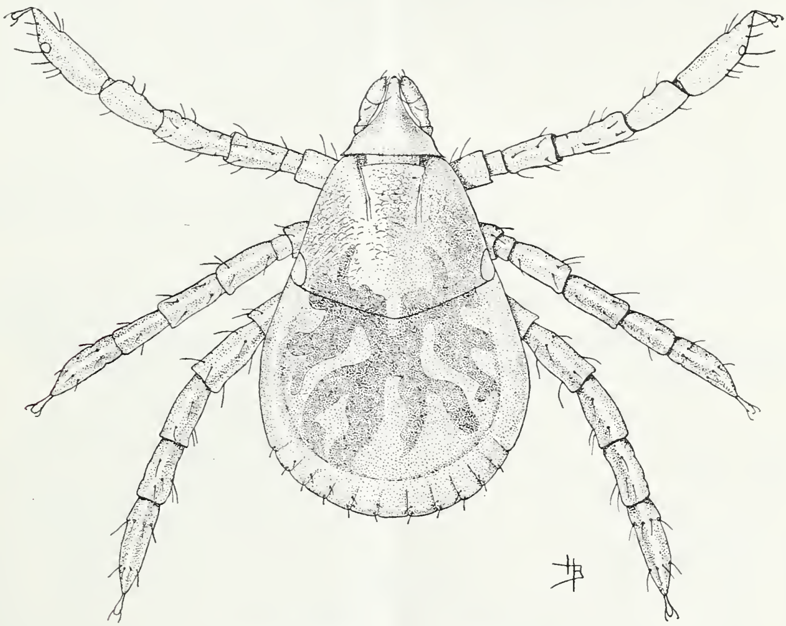

FIGURE 9.—Dorsal aspect of larva of *Dermacentor variabilis.* × 83.

water at intervals, will survive long periods. Larvae kept in tubes in the soil in favorable locations have been observed to live from 8 to 11 months. In the laboratory the longevity of larvae, if kept under moist conditions, is similar. The maximum period observed was between 345 and 377 days. Larvae 318 days old when put on a host attached and became engorged.

The larvae remain in masses on the soil or on low-growing vegetation while awaiting a host. They appear to scatter and crawl about more in warm than in cool weather.

#### LARVAL ENGORGEMENT

In a series of tests to determine how old larvae must be to attach, groups were put on suitable hosts during July 1934 on successive days after hatching. None of those 1 day old attached. A few of those 2 days old attached and became engorged. Those 3 or more days old attached and engorged readily, though the largest percentage of engorgement occurred among larvae 5 or more days old.

The shortest period of engorgement of larvae recorded was 2 days. This occurred in a series of infestations on a pine mouse. In most other cases the minimum engorgement period was 3 days. The maximum engorgement period was 12 days and the average was 4.14 days, based on 10,543 larvae, the engorgement time of which was recorded in these studies. Of these, 5,280 larvae dropped engorged on the fourth day. During winter the period of dropping of engorged larvae was distinctly prolonged; the period of engorgement, however, was practically identical whether the infested hosts were kept in a warm or a cool room.

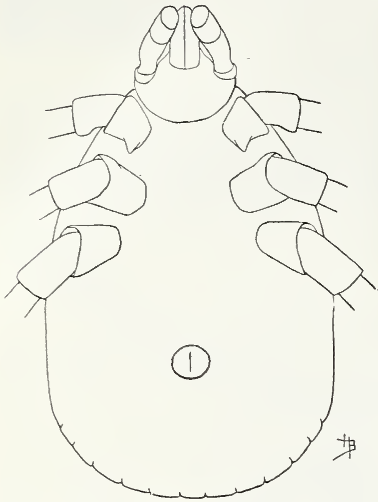

FIGURE 10.—Ventral aspect of larva of *Dermacentor variabilis*. × 85.

Larvae attach mainly around the head of a host, though some are found on the neck and shoulders and occasionally elsewhere on the body.

The engorged larvae seek protection on the soil surface and become quiescent in a few hours to 2 days, depending on the temperature.

Some records on engorgement of larvae are shown in table 3.

TABLE 3.—*Engorgement of larvae of Dermacentor variabilis*

| Breeding No. | Date put on host | Host | Larvae that dropped engorged on the specified day following application | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2d | 3d | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | |
| | | | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* | *No.* |
| | *1933* | | | | | | | | | | | | | |
| 268 | June 22 | Pine mouse | | | 12 | 8 | 1 | | | | | | | 21 |
| 271 | June 28 | do | | 76 | 58 | | | | | | | | | 134 |
| 290 | July 17 | do | | 191 | 225 | | | | | | | | | 416 |
| 358 | Aug. 28 | do | 2 | 183 | 167 | 34 | 6 | | | | | | | 392 |
| 378 | Sept. 11 | do | | 70 | 127 | 14 | 2 | | | | | | | 213 |
| 392 | Sept. 25 | do | | 69 | 51 | 12 | | | | | | | | 132 |
| 393 | do | White-footed mouse | | 2 | 9 | 9 | 5 | | | | | | | 25 |
| 412 | Dec. 27 | Pine mouse | | 51 | 460 | 57 | 33 | 2 | | | | | | 603 |
| 413 | do | House mouse | | 15 | 178 | 29 | 24 | 3 | 0 | 6 | 0 | 0 | 1 | 256 |
| | *1934* | | | | | | | | | | | | | |
| 438 | Jan. 5 | Meadow mouse | | 58 | 292 | 106 | 55 | 44 | 22 | 4 | | | | 581 |
| 439 | do | White-footed mouse | | 1 | 33 | 27 | 28 | 20 | 20 | 9 | 17 | 8 | [1] 6 | 169 |
| 441 | do | Meadow mouse | | | 295 | 86 | 50 | 35 | 16 | 16 | 5 | 2 | | 505 |
| 442 | do | White-footed mouse | | | 31 | 29 | 15 | 10 | 7 | 8 | 6 | 6 | [1] 4 | 116 |
| 499 | Jan. 20 | Meadow mouse | | 62 | 500 | 158 | 83 | 15 | 4 | 1 | | | | 823 |
| 500 | do | White-footed mouse | | 446 | 230 | 61 | 51 | 5 | 8 | 2 | | | | 803 |
| 501 | do | Meadow mouse | | 70 | 480 | 65 | 35 | 16 | 5 | | | | | 671 |
| 502 | do | White-footed mouse | | 3 | 10 | 1 | 8 | 5 | 1 | | | | | 28 |
| 586 | Feb. 12 | Meadow mouse | | 62 | 635 | 42 | 13 | 2 | | | | | | 754 |
| 590 | do | Pine mouse | | 248 | 118 | 41 | 15 | 3 | | | | | | 425 |
| 591 | do | White-footed mouse | | 9 | 15 | 27 | 2 | 1 | 2 | 3 | 2 | | | 61 |
| 696 | Mar. 20 | Meadow mouse | | 145 | 67 | 89 | 9 | 1 | | | | | | 311 |
| 698 | do | White-footed mouse | | 8 | 3 | 1 | 2 | | | | | | | 14 |
| 746 | Apr. 23 | Meadow mouse | | 3 | 50 | 91 | 58 | 19 | 6 | 1 | | | | 228 |
| 832 | June 28 | do | | | | 2 | 1 | | | | | | | 3 |
| 842 | July 13 | do | | 31 | 166 | 9 | | | | | | | | 206 |
| 966 | Nov. 2 | do | | 26 | 306 | 29 | 31 | | | | | | | 392 |
| 978 | Dec. 21 | do | | 50 | 283 | 189 | 56 | | | | | | | 578 |
| | *1936* | | | | | | | | | | | | | |
| 1026 | Mar. 31 | White-footed mouse | | | 26 | 23 | 12 | 17 | | | | | | 78 |
| 1032 | Apr. 8 | do | | | 7 | 10 | 4 | | | | | | | 21 |
| 1041 | Apr. 16 | White rat | | | 2 | 2 | 6 | 7 | 4 | | | | | 21 |
| | *1937* | | | | | | | | | | | | | |
| 1142 | Jan. 7 | White-footed mouse | | | 481 | 288 | 61 | 16 | | | | | | 846 |

[1] Some larvae still attached on this day.

LARVAL MOLTING

The period from dropping to molting is markedly influenced by temperature, as shown in figure 11. The shortest molting period was 6 days. This occurred in July 1933, when the average daily mean temperature was 84.5° F., and in July 1934, when the mean temperature was 81.5° to 84°. The maximum period required for molting

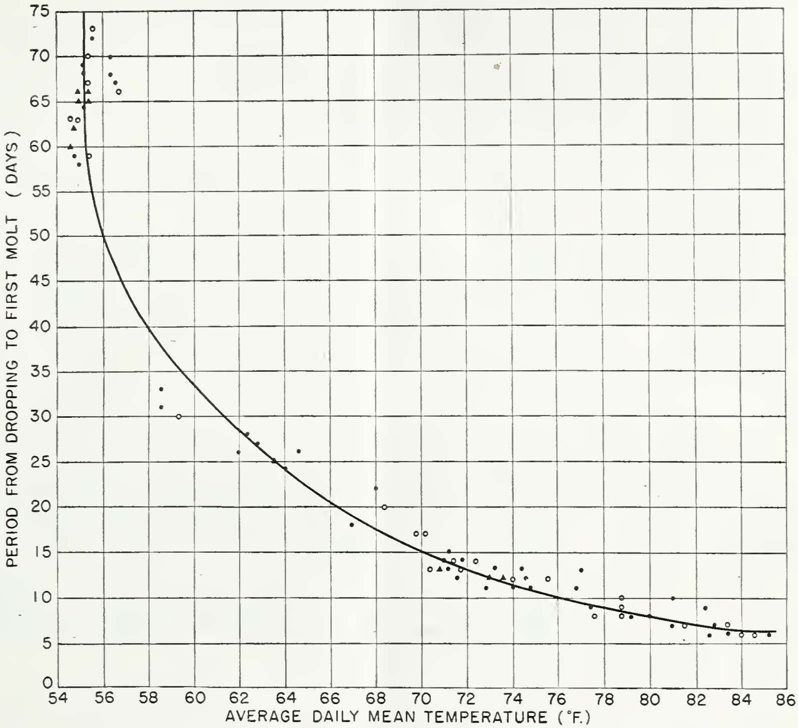


FIGURE 11.—Molting of larvae of *Dermacentor variabilis.* Dots represent single records, circles represent two records, and triangles represent three records.

was 87 days. During this period the minimum temperature was 36°, the maximum 75°, and the mean 55.1° F.

The marked effect of temperature on the molting period is illustrated by two lots of engorged larvae dropped on the same date. The one kept in the laboratory at an average daily mean temperature of 74.4° F. began molting on the sixteenth day, while the one kept out of doors at a mean temperature of 55.3° did not begin molting until the sixty-sixth day. Representative records of the molting of larvae at high and low temperatures are shown in tables 4 and 5.

TABLE 4.—*Molting of larvae of Dermacentor variabilis at moderate temperatures*

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 6th | 7th | 8th | 9th | 10th | 11th | 12th | 13th | 14th |
| | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | | | | | | | | | | | |
| July 19 | Pine mouse | 120 | ------ | 18 | 38 | 18 | 8 | 3 | ------ | ------ | ------ |
| 20 | do | 71 | 5 | 28 | 21 | 12 | 1 | 1 | 1 | ------ | ------ |
| 20 | do | 217 | 30 | 136 | 32 | 10 | 4 | 3 | ------ | ------ | ------ |
| Aug. 15 | do | 20 | ------ | ------ | 1 | 4 | 11 | 4 | ------ | ------ | ------ |
| 30 | do | 105 | ------ | ------ | ------ | 10 | 82 | 9 | 1 | ------ | ------ |
| 31 | do | 152 | ------ | ------ | 14 | 100 | 32 | 1 | ------ | ------ | ------ |
| Sept. 13 | do | 47 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 15 | 24 |
| 14 | do | 126 | ------ | ------ | ------ | ------ | ------ | ------ | 49 | 64 | 6 |
| 28 | do | 64 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 9 | 37 |
| 28 | do | 35 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 8 | 16 |
| 30 | White-footed mouse | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 1 | 1 |
| Oct. 1 | do | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 2 | 1 |
| *1934* | | | | | | | | | | | |
| Jan. 10[1] | Meadow mouse | 106 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 11[1] | White-footed mouse | 28 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 23[1] | do | 446 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 24[1] | Meadow mouse | 300 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 28[1] | White-footed mouse | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Mar. 23[1] | Meadow mouse | 146 | ------ | ------ | ------ | ------ | ------ | ------ | 14 | 72 | 43 |
| 26[1] | do | 9 | ------ | ------ | ------ | ------ | 1 | 3 | 3 | 1 | 1 |
| Apr. 27 | do | 50 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 7 | 24 |
| 28 | do | 91 | ------ | ------ | ------ | ------ | ------ | ------ | 11 | 57 | 12 |
| 29 | do | 58 | ------ | ------ | ------ | ------ | ------ | 10 | 33 | 9 | 6 |
| July 19 | Pine mouse | 11 | 11 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1936* | | | | | | | | | | | |
| Apr. 4 | White-footed mouse | 26 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 12 | do | 7 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 13 | do | 10 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 15th | 16th | 17th | 18th | 19th | 20th | 21st | 22d | 23d |
| | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | | | | | | | | | | | |
| July 19 | Pine mouse | 120 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 20 | do | 71 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 20 | do | 217 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Aug. 15 | do | 20 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 30 | do | 105 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 31 | do | 152 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Sept. 13 | do | 47 | 7 | 1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 14 | do | 126 | 2 | 3 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 28 | do | 64 | 15 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 28 | do | 35 | 9 | 0 | 1 | 1 | ------ | ------ | ------ | ------ | ------ |
| 30 | White-footed mouse | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Oct. 1 | do | 5 | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1934* | | | | | | | | | | | |
| Jan. 10[1] | Meadow mouse | 106 | 1 | 18 | 27 | 36 | 13 | 5 | 2 | 1 | 0 |
| 11[1] | White-footed mouse | 28 | ------ | 4 | 5 | 4 | 1 | 2 | 1 | 1 | 1 |
| 23[1] | do | 446 | ------ | ------ | 2 | 38 | 145 | 74 | 130 | 37 | 6 |
| 24[1] | Meadow mouse | 300 | ------ | ------ | 4 | 29 | 42 | 127 | 67 | 14 | 5 |
| 28[1] | White-footed mouse | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 2 | 2 |
| Mar. 23[1] | Meadow mouse | 146 | 8 | 1 | 3 | 2 | 2 | 1 | ------ | ------ | ------ |
| 26[1] | do | 9 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Apr. 27 | do | 50 | 5 | 7 | 1 | 1 | 1 | 0 | 1 | ------ | ------ |
| 28 | do | 91 | 5 | 2 | 1 | ------ | ------ | ------ | ------ | ------ | ------ |
| 29 | do | 58 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| July 19 | Pine mouse | 11 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1936* | | | | | | | | | | | |
| Apr. 4 | White-footed mouse | 26 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 12 | do | 7 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 13 | do | 10 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

TABLE 4.—*Molting of larvae of Dermacentor variabilis at moderate temperatures*—Continued

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 24th | 25th | 26th | 27th | 28th | 29th | 30th | 31st | 32d |
| *1933* | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| July 19 | Pine mouse | 120 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 20 | do | 71 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 20 | do | 217 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Aug. 15 | do | 20 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 30 | do | 105 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 31 | do | 152 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Sept. 13 | do | 47 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 14 | do | 126 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 28 | do | 64 | 0 | 0 | 1 | ------ | ------ | ------ | ------ | ------ | ------ |
| 28 | do | 35 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 30 | White-footed mouse | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Oct. 1 | do | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1934* | | | | | | | | | | | |
| Jan. 10 [1] | Meadow mouse | 106 | 2 | 0 | 0 | 0 | 0 | 1 | ------ | ------ | ------ |
| 11 [1] | White-footed mouse | 28 | 1 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 0 |
| 23 [1] | do | 446 | 1 | 0 | 1 | 1 | 1 | 0 | 2 | ------ | ------ |
| 24 [1] | Meadow mouse | 300 | 2 | 3 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 28 [1] | White-footed mouse | 8 | 0 | 0 | 0 | 3 | ------ | ------ | ------ | ------ | ------ |
| Mar. 23 [1] | Meadow mouse | 146 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 26 [1] | do | 9 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Apr. 27 | do | 50 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 28 | do | 91 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 29 | do | 58 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| July 19 | Pine mouse | 11 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1936* | | | | | | | | | | | |
| Apr. 4 | White-footed mouse | 26 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 12 | do | 7 | ------ | ------ | 1 | 4 | 0 | 0 | 0 | 1 | ------ |
| 13 | do | 10 | ------ | 3 | 5 | 1 | 1 | ------ | ------ | ------ | ------ |

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | Larvae molted | Temperature from dropping to first molt | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 33d | 34th | 35th | 36th | | Maximum | Minimum | Average daily mean |
| *1933* | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | °*F.* | °*F.* | °*F.* |
| July 19 | Pine mouse | 120 | ------ | ------ | ------ | ------ | 85 | 90 | 79 | 84.2 |
| 20 | do | 71 | ------ | ------ | ------ | ------ | 69 | 90 | 81 | 84.5 |
| 20 | do | 217 | ------ | ------ | ------ | ------ | 215 | 90 | 81 | 84.5 |
| Aug. 15 | do | 20 | ------ | ------ | ------ | ------ | 20 | 83 | 73 | 79.3 |
| 30 | do | 105 | ------ | ------ | ------ | ------ | 102 | 82 | 72 | 77.4 |
| 31 | do | 152 | ------ | ------ | ------ | ------ | 147 | 82 | 72 | 77.6 |
| Sept. 13 | do | 47 | ------ | ------ | ------ | ------ | 47 | 83 | 67 | 73.1 |
| 14 | do | 126 | ------ | ------ | ------ | ------ | 124 | 83 | 67 | 73.1 |
| 28 | do | 64 | ------ | ------ | ------ | ------ | 64 | 81 | 66 | 71.8 |
| 28 | do | 35 | ------ | ------ | ------ | ------ | 35 | 81 | 66 | 71.8 |
| 30 | White-footed mouse | 2 | ------ | ------ | ------ | ------ | 2 | 77 | 66 | 70.6 |
| Oct. 1 | do | 5 | ------ | ------ | ------ | ------ | 5 | 77 | 66 | 70.4 |
| *1934* | | | | | | | | | | |
| Jan. 10 [1] | Meadow mouse | 106 | ------ | ------ | ------ | ------ | 106 | 82 | 65 | 73.5 |
| 11 [1] | White-footed mouse | 28 | 1 | ------ | ------ | ------ | 28 | 83 | 65 | 74.4 |
| 23 [1] | do | 446 | ------ | ------ | ------ | ------ | 438 | 83 | 60 | 73.0 |
| 24 [1] | Meadow mouse | 300 | ------ | ------ | ------ | ------ | 293 | 83 | 60 | 72.5 |
| 28 [1] | White-footed mouse | 8 | ------ | ------ | ------ | ------ | 7 | 80 | 60 | 70.6 |
| Mar. 23 [1] | Meadow mouse | 146 | ------ | ------ | ------ | ------ | 146 | 88 | 64 | 76.0 |
| 26 [1] | do | 9 | ------ | ------ | ------ | ------ | 9 | 88 | 69 | 77.9 |
| Apr. 27 | do | 50 | ------ | ------ | ------ | ------ | 47 | 86 | 59 | 71.3 |
| 28 | do | 91 | ------ | ------ | ------ | ------ | 88 | 86 | 59 | 71.8 |
| 29 | do | 58 | ------ | ------ | ------ | ------ | 58 | 86 | 61 | 72.7 |
| July 19 | Pine mouse | 11 | ------ | ------ | ------ | ------ | 11 | 87 | 79 | 83.8 |
| *1936* | | | | | | | | | | |
| Apr. 4 | White-footed mouse | 26 | 2 | 16 | 3 | 1 | 22 | 87 | 36 | 58.6 |
| 12 | do | 7 | ------ | ------ | ------ | ------ | 6 | 87 | 45 | 62.0 |
| 13 | do | 10 | ------ | ------ | ------ | ------ | 10 | 88 | 45 | 63.5 |

[1] Kept in a heated room.

TABLE 5.—*Molting of larvae of Dermacentor variabilis at low temperatures*

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 58th | 59th | 60th | 61st | 62d | 63d | 64th | 65th | 66th |
| *1934* | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| Jan. 9 | Meadow mouse | 295 | ------ | 24 | 10 | 3 | 5 | 32 | 27 | 26 | 32 |
| 10 | do | 86 | ------ | ------ | ------ | ------ | ------ | 1 | 5 | 4 | 11 |
| 11 | do | 50 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 3 |
| 12 | do | 36 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 2 | 8 |
| 13 | do | 16 | ------ | ------ | ------ | ------ | ------ | 1 | 0 | 1 | 0 |
| 14 | do | 16 | ------ | ------ | ------ | ------ | 1 | 0 | 1 | 0 | 0 |
| 14 | White-footed mouse | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 23 | Meadow mouse | 70 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 2 |
| 24 | do | 480 | ------ | ------ | ------ | ------ | ------ | ------ | 33 | 35 | 43 |
| 25 | do | 65 | ------ | ------ | ------ | ------ | ------ | 1 | 1 | 1 | 4 |
| 26 | do | 35 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 1 |
| 29 | do | 66 | ------ | ------ | ------ | ------ | 2 | 9 | 25 | 11 | 4 |
| 30 | do | 58 | ------ | ------ | 3 | 6 | 13 | 25 | 2 | 1 | 1 |
| Feb. 1 | do | 7 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 1 |

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 67th | 68th | 69th | 70th | 71st | 72d | 73d | 74th | 75th |
| *1934* | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| Jan. 9 | Meadow mouse | 295 | 35 | 24 | 15 | 7 | 11 | 7 | 8 | 2 | 2 |
| 10 | do | 86 | 7 | 7 | 2 | 4 | 6 | 2 | 0 | 0 | 1 |
| 11 | do | 50 | 0 | 1 | 4 | 4 | 1 | 0 | 0 | 0 | 7 |
| 12 | do | 36 | 0 | 3 | 0 | 3 | 0 | 3 | 4 | 1 | 3 |
| 13 | do | 16 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 14 | do | 16 | 0 | 2 | 0 | 0 | 0 | 1 | 2 | 1 | 0 |
| 14 | White-footed mouse | 8 | ------ | ------ | ------ | ------ | ------ | ------ | 1 | 0 | 2 |
| 23 | Meadow mouse | 70 | 7 | 7 | 9 | 29 | 5 | 2 | 3 | 0 | 2 |
| 24 | do | 480 | 55 | 82 | 125 | 21 | 7 | 11 | 13 | 9 | 10 |
| 25 | do | 65 | 11 | 18 | 6 | 4 | 0 | 1 | 2 | 4 | 5 |
| 26 | do | 35 | 9 | 4 | 4 | 3 | 0 | 4 | 5 | 0 | 1 |
| 29 | do | 66 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 |
| 30 | do | 58 | 1 | 1 | 1 | ------ | ------ | ------ | ------ | ------ | ------ |
| Feb. 1 | do | 7 | 1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 76th | 77th | 78th | 79th | 80th | 81st | 82d | 83d | 84th |
| *1934* | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| Jan. 9 | Meadow mouse | 295 | 1 | 3 | 0 | 0 | 3 | 2 | 2 | 0 | 1 |
| 10 | do | 86 | 1 | 8 | 0 | 3 | 3 | 0 | 4 | 7 | 0 |
| 11 | do | 50 | 4 | 2 | 2 | 5 | 1 | 0 | 7 | 1 | 0 |
| 12 | do | 36 | 0 | 1 | 2 | 2 | 1 | 2 | 0 | 1 | ------ |
| 13 | do | 16 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | ------ |
| 14 | do | 16 | 1 | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 0 |
| 14 | White-footed mouse | 8 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 23 | Meadow mouse | 70 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | do | 480 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| 25 | do | 65 | 1 | 1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 26 | do | 35 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 29 | do | 66 | 0 | 1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 30 | do | 58 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Feb. 1 | do | 7 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

| Date engorged larvae dropped | Host | Larvae dropped | Larvae that molted on the specified day following dropping | | | Larvae molted | Temperature from dropping to first molt | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 85th | 86th | 87th | | Maximum | Minimum | Average daily mean |
| *1934* | | *Number* | *Number* | *Number* | *Number* | *Number* | °*F.* | °*F.* | °*F.* |
| Jan. 9 | Meadow mouse | 295 | ------ | ------ | ------ | 282 | 75 | 36 | 54.6 |
| 10 | do | 86 | 1 | ------ | ------ | 77 | 75 | 36 | 54.6 |
| 11 | do | 50 | 1 | ------ | ------ | 43 | 75 | 36 | 55.1 |
| 12 | do | 36 | ------ | ------ | ------ | 36 | 75 | 36 | 55.0 |
| 13 | do | 16 | ------ | ------ | ------ | 12 | 75 | 36 | 54.8 |
| 14 | do | 16 | 1 | ------ | ------ | 16 | 75 | 36 | 54.7 |
| 14 | White-footed mouse | 8 | 0 | 1 | ------ | 7 | 75 | 36 | 55.5 |
| 23 | Meadow mouse | 70 | 0 | 1 | ------ | 70 | 75 | 36 | 55.3 |
| 24 | do | 480 | 0 | 0 | 1 | 452 | 75 | 36 | 55.1 |
| 25 | do | 65 | ------ | ------ | ------ | 60 | 75 | 36 | 55.0 |
| 26 | do | 35 | ------ | ------ | ------ | 31 | 75 | 36 | 55.3 |
| 29 | do | 66 | ------ | ------ | ------ | 62 | 75 | 36 | 54.9 |
| 30 | do | 58 | ------ | ------ | ------ | 54 | 75 | 36 | 54.8 |
| Feb. 1 | do | 7 | ------ | ------ | ------ | 7 | 75 | 36 | 55.1 |

### NYMPH

The nymph (figs. 12 and 13) is similar to the larva in appearance, but has four pairs of legs and is about 1.5 mm in length. Unengorged specimens are pale yellowish brown, with the hind border of the shield dark brown and the sides of the shield brick red. In living specimens the intestines are visible as brown bands through the body wall. Engorged individuals are slate gray.

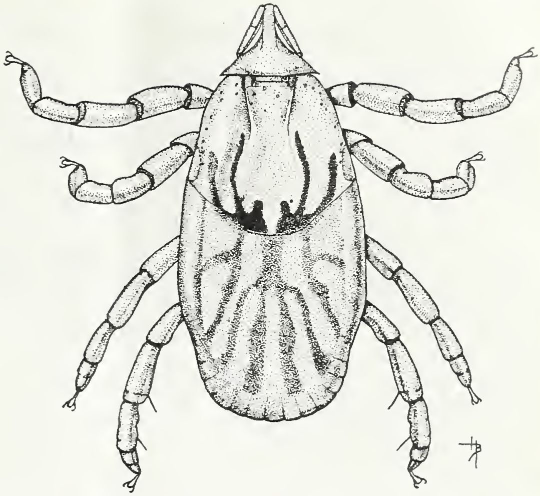

FIGURE 12.—Dorsal aspect of nymph of *Dermacentor variabilis*. × 38.


FIGURE 13.—*A*, ventral aspect of a portion of a nymph of *Dermacentor variabilis*, × 36; *B*, stigmal plate, × 110.

### NYMPHAL LONGEVITY

The maximum longevity of unfed nymphs kept in tubes on moist sand in the laboratory was between 274 and 309 days. Several other lots showed some nymphs surviving 259, 271, 245 to 275, and 259 to 291 days. The longevity of most of the nymphs did not exceed 6 months.

One lot of 36 nymphs which molted from larvae September 28 to 30, 1933, were kept in an unheated room until June 28, 1934, an interval of 271 to 273 days. Three nymphs were still alive at this time, and when put on a meadow mouse two of them engorged.

### NYMPHAL ENGORGEMENT

The engorgement period of nymphs was between 3 and 10 days, with an average of 5.2 days. This is based on accurate records kept on 414 nymphs which became replete in laboratory tests.

Newly molted nymphs are relatively inactive for 1 to 4 days, but 1 nymph out of 15 applied to a host on the same day molting occurred became engorged. On the second day after molting, nymphs attached and engorged readily.

Records of the engorgement of nymphs are shown in table 6.

TABLE 6.—*Engorgement of nymphs of Dermacentor variabilis*

| Date put on host | Host | Nymphs that dropped engorged on the specified day following application | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3d | 4th | 5th | 6th | 7th | 8th | 9th | 10th | |
| | | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* | *Number* |
| *1933* | | | | | | | | | | |
| July 17 | Pine mouse | | 2 | 2 | | | | | | 4 |
| 29 | do | | 3 | 4 | | | | | | 7 |
| 29 | do | | | 5 | 2 | | | | | 7 |
| Aug. 14 | do | | 2 | 2 | | | | | | 4 |
| *1934* | | | | | | | | | | |
| Jan. 16 | Meadow mouse | | | 14 | 1 | 1 | | | | 16 |
| 26 | do | | 33 | 13 | 17 | 0 | 1 | 0 | 1 | 65 |
| 26 | White-footed mouse | | 3 | 0 | 1 | | | | | 4 |
| Feb. 5 | Meadow mouse | | 3 | 10 | 5 | 5 | | | | 23 |
| 28 | do | | 4 | 20 | 5 | | | | | 29 |
| 28 | do | | 1 | 17 | 8 | 3 | | | | 29 |
| Mar. 13 | do | | 1 | 8 | 2 | | | | | 11 |
| 28 | do | | | 3 | 4 | 2 | | | | 9 |
| May 1 | do | | 1 | 1 | 3 | | | | | 5 |
| 1 | do | | | 2 | 1 | 0 | 0 | 1 | | 4 |
| Apr. 23 | do | | | 3 | 4 | 0 | 1 | | | 8 |
| May 9 | do | | | 14 | | | | | | 14 |
| 16 | do | | | 7 | 1 | | | | | 8 |
| 29 | do | | | | | 1 | 2 | | | 3 |
| June 13 | do | | | | 7 | | | | | 7 |
| Aug. 8 | do | | | 8 | 0 | 1 | | | | 9 |
| Sept. 10 | do | 2 | 4 | 1 | | | | | | 7 |
| 16 | do | 1 | 4 | 1 | | | | | | 6 |
| *1935* | | | | | | | | | | |
| June 11 | Guinea pig | | | | 5 | 3 | 8 | 3 | | 19 |

NYMPHAL MOLTING

The shortest molting period noted (2 instances) in the course of the tests here reported was 17 days. The maximum, minimum, and mean temperatures during each of these periods were 92°, 75°, and 83° F., respectively. Hooker, Bishopp, and Wood (*6*) have reported a minimum nymphal molting period of 16 days. The maximum molting period observed was 105 to 109 days. This occurred in the case of a lot of nymphs dropped on September 16, 1934. As noted in table 7, two of the nymphs molted on the thirtieth and thirty-first days and the other one did not molt until the period between December 30, 1934, and January 3, 1935. The molting period is greatly lengthened during cold weather. The relationship between the length of the period and temperature is practically identical with that of the larval molting period, as shown in figure 11.

Records of molting of nymphs in summer and in winter are given in tables 7 and 8, respectively.

TABLE 7.—*Molting of nymphs of Dermacentor variabilis in summer*

| Date engorged nymphs dropped | Host | Nymphs dropped | Number and sex [1] of nymphs that molted on the specified day following dropping | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 17th | 18th | 19th | 20th | 21st | 22d | 23d |
| *1933* | | *Number* | | | | | | | |
| Apr. 5 | White-footed mouse | 1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| June 26 | Guinea pig | 2 | ---- | ---- | ---- | ---- | 1♀ | 0 | 1♀ |
| July 20 | Pine mouse | 2 | 1♀ | 0 | 1♂ | ---- | ---- | ---- | ---- |
| 21 | do | 20 | ---- | ---- | 1♂,2♀ | 2♂,1♀ | 2♂ | 1♂,4♀ | 0 |
| Aug. 2 | do | 3 | ---- | ---- | 1♂ | 1♀ | 1♂ | ---- | ---- |
| 2 | do | 4 | ---- | ---- | ---- | 1♂ | 0 | 1♂,1♀ | 1♂ |
| 3 | do | 5 | ---- | ---- | ---- | ---- | 1♀ | 0 | 3♂ |
| 18 | do | 2 | ---- | ---- | ---- | ---- | 1♀ | 1♀ | ---- |
| 18 | do | 2 | ---- | ---- | 1♂ | 0 | 0 | 1♀ | ---- |
| *1934* | | | | | | | | | |
| Apr. 2 [2] | Meadow mouse | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 2 [2] | Pine mouse | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 3 [2] | Meadow mouse | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 29 | do | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| May 7 | do | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 14 | do | 14 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 21 | do | 5 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| June 4 | Pine mouse | 4 | ---- | ---- | ---- | ---- | 2♀ | 1♂,1♀ | ---- |
| 19 | Meadow mouse | 5 | 1♀ | 1♂,3♀ | ---- | ---- | ---- | ---- | ---- |
| July 5 | do | 2 | ---- | 1♂ | 1♀ | ---- | ---- | ---- | ---- |
| Aug. 13 | do | 6 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 13 | do | 8 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Sept. 13 | do | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 16 | do | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 20 | do | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| Date engorged nymphs dropped | Host | Nymphs dropped | Number and sex [1] of nymphs that molted on the specified day following dropping | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 24th | 25th | 26th | 27th | 28th | 29th | 30th |
| *1933* | | *Number* | | | | | | | |
| Apr. 5 | White-footed mouse | 1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| June 26 | Guinea pig | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| July 20 | Pine mouse | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 21 | do | 20 | 1♂, 1♀ | ---- | ---- | ---- | ---- | ---- | ---- |
| Aug. 2 | do | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 2 | do | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 3 | do | 5 | 0 | 0 | 1♀ | ---- | ---- | ---- | ---- |
| 18 | do | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 18 | do | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| *1934* | | | | | | | | | |
| Apr. 2 [2] | Meadow mouse | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 2 [2] | Pine mouse | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 3 [2] | Meadow mouse | 2 | ---- | ---- | ---- | ---- | ---- | ---- | 1♀ |
| 29 | do | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| May 7 | do | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 14 | do | 14 | ---- | ---- | ---- | ---- | 1♀ | 1♂, 4♀ | 2♂, 3♀ |
| 21 | do | 5 | 1♀ | 1♂ | 1♀ | 0 | 1♂ | ---- | ---- |
| June 4 | Pine mouse | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 19 | Meadow mouse | 5 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| July 5 | do | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Aug. 13 | do | 6 | ---- | ---- | ---- | 1♂ | 1♂, 1♀ | 0 | 1♀ |
| 13 | do | 8 | ---- | ---- | 2♀ | 1♀ | 1♂ | 2♀ | 2♂ |
| Sept. 13 | do | 2 | ---- | 1♂, 1♀ | ---- | ---- | ---- | ---- | ---- |
| 16 | do | 4 | ---- | ---- | ---- | ---- | ---- | ---- | 1♀ |
| 20 | do | 3 | ---- | ---- | 1♀ | 1♀ | ---- | ---- | ---- |

[1] ♂=males; ♀=females. [2] Kept in artificially heated room.

TABLE 7.—*Molting of nymphs of Dermacentor variabilis in summer*—Continued

| Date engorged nymphs dropped | Host | Nymphs dropped | Number and sex [1] of nymphs that molted on the specified day following dropping | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 31st | 32d | 33d | 34th | 35th | 36th | 37th | 38th |
| *1933* | | *Number* | | | | | | | | |
| Apr. 5 | White-footed mouse | 1 | ------ | | | | 1♀ | ------ | ------ | ------ |
| June 26 | Guinea pig | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| July 20 | Pine mouse | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 21 | do | 20 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Aug. 2 | do | 3 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 2 | do | 4 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 3 | do | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 18 | do | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 18 | do | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| *1934* | | | | | | | | | | |
| Apr. 2 [2] | Meadow mouse | 3 | ------ | ------ | ------ | 1♀ | 1♂ | 0 | 1♂ | ------ |
| 2 [2] | Pine mouse | 4 | ------ | ------ | 3♀ | 1♀ | ------ | ------ | ------ | ------ |
| 3 [2] | Meadow mouse | 2 | 0 | 0 | 1♀ | ------ | ------ | ------ | ------ | ------ |
| 29 | do | 4 | ------ | ------ | ------ | 1♀ | 0 | 1♂ | 2♂ | ------ |
| May 7 | do | 3 | ------ | 1♀ | 0 | 1♀ | 0 | 0 | 0 | 1♂ |
| 14 | do | 14 | 2♂ | 0 | 1♂ | ------ | ------ | ------ | ------ | ------ |
| 21 | do | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| June 4 | Pine mouse | 4 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 19 | Meadow mouse | 5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| July 5 | do | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Aug. 13 | do | 6 | 2♀ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 13 | do | 8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| Sept. 13 | do | 2 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 16 | do | 4 | 1♂ | ------ | ------ | ------ | ------ | ------ | ------ | (3) |
| 20 | do | 3 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | (4) |

| Date engorged nymphs dropped | Host | Nymphs dropped | Nymphs molted | | | Temperature from dropping to first molt | | |
|---|---|---|---|---|---|---|---|---|
| | | | ♂ | ♀ | Total | Maximum | Minimum | Average daily mean |
| *1933* | | *Number* | *Number* | *Number* | *Number* | °*F.* | °*F.* | °*F.* |
| Apr. 5 | White-footed mouse | 1 | ------ | 1 | 1 | 85 | 58 | 72.3 |
| June 26 | Guinea pig | 2 | ------ | 2 | 2 | 91 | 70 | 79.6 |
| July 20 | Pine mouse | 2 | 1 | 1 | 2 | 92 | 75 | 83.2 |
| 21 | do | 20 | 7 | 8 | 15 | 92 | 75 | 82.7 |
| Aug. 2 | do | 3 | 2 | 1 | 3 | 92 | 75 | 80.9 |
| 2 | do | 4 | 3 | 1 | 4 | 92 | 73 | 80.7 |
| 3 | do | 5 | 3 | 2 | 5 | 89 | 73 | 79.8 |
| 18 | do | 2 | ------ | 2 | 2 | 86 | 72 | 78.5 |
| 18 | do | 2 | 1 | 1 | 2 | 86 | 72 | 78.6 |
| *1934* | | | | | | | | |
| Apr. 2 [2] | Meadow mouse | 3 | 2 | 1 | 3 | 88 | 66 | 75.8 |
| 2 [2] | Pine mouse | 4 | ------ | 4 | 4 | 88 | 66 | 75.6 |
| 3 [2] | Meadow mouse | 2 | ------ | 2 | 2 | 88 | 66 | 75.3 |
| 29 | do | 4 | 3 | 1 | 4 | 86 | 61 | 71.2 |
| May 7 | do | 3 | 1 | 2 | 3 | 86 | 62 | 72.6 |
| 14 | do | 14 | 6 | 8 | 14 | 84 | 62 | 72.1 |
| 21 | do | 5 | 2 | 2 | 4 | 84 | 62 | 73.5 |
| June 4 | Pine mouse | 4 | 1 | 3 | 4 | 86 | 72 | 77.5 |
| 19 | Meadow mouse | 5 | 1 | 4 | 5 | 92 | 75 | 83.0 |
| July 5 | do | 2 | 1 | 1 | 2 | 90 | 75 | 82.2 |
| Aug. 13 | do | 6 | 2 | 4 | 6 | 84 | 59 | 72.8 |
| 13 | do | 8 | 3 | 5 | 8 | 84 | 59 | 72.8 |
| Sept. 13 | do | 2 | 1 | 1 | 2 | 79 | 61 | 69.8 |
| 16 | do | 4 | 1 | 2 | 3 | 76 | 56 | 68.8 |
| 20 | do | 3 | 1 | 2 | 3 | 76 | 56 | 68.7 |

[1] ♂=males; ♀=females.
[2] Kept in artificially heated room.
[3] 1 female molted 105 to 109 days after dropping.
[4] 1 male molted 100 to 105 days after dropping.

TABLE 8.—*Molting of nymphs of Dermacentor variabilis in winter on meadow mouse*

| Date engorged nymphs dropped | Nymphs dropped | Number and sex [1] of nymphs that molted during specified periods after dropping | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 to 34 days | 35 to 39 days | 40 to 44 days | 45 to 49 days | 50 to 54 days | 55 to 59 days | 60 to 64 days | 65 to 69 days | 70 to 74 days |
| *1934* | *Number* | | | | | | | | | |
| Jan. 30 | 33 | ---------- | ---------- | ---------- | 1♂ | 1♂, 3♀ | 1♀ | 2♂, 5♀ | 5♂, 5♀ | 2♂ |
| 31 [2] | 30 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |
| 31 | 13 | ---------- | ---------- | ---------- | ---------- | ---------- | 1♂ | 1♂, 2♀ | 1♂, 2♀ | 2♀ |
| Feb. 1 [2] | 3 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |
| 1 | 17 | ---------- | ---------- | ---------- | ---------- | ---------- | 1♀ | 1♂, 2♀ | 2♂, 3♀ | 1♂, 3♀ |
| 9 | 48 | ---------- | ---------- | ---------- | 3♂, 3♀ | 12♂, 7♀ | 3♂, 4♀ | 3♂, 3♀ | 2♂, 1♀ | ---------- |
| 9 | 8 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | 1♂, 2♀ | ---------- | ---------- |
| 10 | 15 | ---------- | ---------- | ---------- | 2♀ | 3♂, 1♀ | 4♂ | 1♂ | ---------- | ---------- |
| 26 | 9 | ---------- | ---------- | ---------- | 2♀ | 2♂ | 1♂, 2♀ | 1♀ | 1♀ | ---------- |
| Mar. 5 | 17 | ---------- | 1♀ | 3♂, 3♀ | 2♂, 4♀ | 1♂, 1♀ | 1♂ | 1♀ | ---------- | ---------- |
| 18 | 8 | ---------- | 2♂, 2♀ | 1♂, 2♀ | ---------- | 1♀ | ---------- | ---------- | ---------- | ---------- |
| 19 | 3 | 1♀ | 1♂ | 1♂ | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |

| Date engorged nymphs dropped | Nymphs dropped | Number and sex [1] of nymphs that molted during specified periods after dropping | | | | | | Period from dropping to molting | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 75 to 79 days | 80 to 84 days | 85 to 89 days | 90 to 94 days | 95 to 99 days | 100 to 104 days | Maximum | | Minimum | |
| | | | | | | | | Male | Female | Male | Female |
| *1934* | *Number* | | | | | | | *Days* | *Days* | *Days* | *Days* |
| Jan. 30 | 33 | 1♂, 1♀ | ---------- | 4♀ | 2♀ | ---------- | ---------- | 78 | 92 | 45 | 51 |
| 31 [2] | 30 | ---------- | ---------- | ---------- | 6♀ | 5♂, 13♀ | 2♂, 1♀ | 102 | 104 | 95 | 90 |
| 31 | 13 | 1♀ | ---------- | ---------- | ---------- | ---------- | ---------- | 65 | 77 | 59 | 61 |
| Feb. 1 [2] | 3 | ---------- | ---------- | ---------- | 1♀ | 1♀ | ---------- | ---------- | 95 | ---------- | 92 |
| 1 | 17 | 2♂ | ---------- | ---------- | 1♀ | 1♀ | ---------- | 76 | 96 | 62 | 56 |
| 9 | 48 | 3♂ | ---------- | 2♂, 1♀ | 1♀ | ---------- | ---------- | 86 | 91 | 46 | 46 |
| 9 | 8 | 1♂ | ---------- | 1♀ | ---------- | 1♀ | 1♂ | 103 | 98 | 61 | 61 |
| 10 | 15 | 1♀ | 1♂ | 1♂ | ---------- | ---------- | 1♀ | 85 | 100 | 50 | 45 |
| 26 | 9 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | 56 | 65 | 51 | 47 |
| Mar. 5 | 17 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | 56 | 60 | 40 | 38 |
| 18 | 8 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | 41 | 50 | 37 | 36 |
| 19 | 3 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | 43 | 33 | 39 | 33 |

| Date engorged nymphs dropped | Nymphs dropped | Nymphs molted | | Temperature from dropping to first molt | | |
|---|---|---|---|---|---|---|
| | | Male | Female | Maximum | Minimum | Average daily mean |
| *1934* | *Number* | *Number* | *Number* | °*F.* | °*F.* | °*F.* |
| Jan. 30 | 33 | 12 | 21 | 88 | 60 | 72.4 |
| Jan. 31 [2] | 30 | 7 | 20 | 80 | 36 | 59.0 |
| Do | 13 | 3 | 7 | 88 | 60 | 72.9 |
| Feb. 1 [2] | 3 | ---------- | 2 | 80 | 36 | 59.6 |
| Do | 17 | 6 | 11 | 88 | 60 | 72.9 |
| Feb. 9 | 48 | 28 | 20 | 88 | 60 | 73.1 |
| Do | 8 | 3 | 4 | 88 | 60 | 74.3 |
| Feb. 10 | 15 | 10 | 5 | 88 | 60 | 73.2 |
| Feb. 26 | 9 | 3 | 6 | 88 | 64 | 75.2 |
| Mar. 5 | 17 | 7 | 10 | 88 | 64 | 75.5 |
| Mar. 18 | 8 | 3 | 5 | 88 | 64 | 75.5 |
| Mar. 19 | 3 | 2 | 1 | 88 | 64 | 75.6 |

[1] ♂=male; ♀=female. [2] Kept in a cold room.

The molting period of males and females was practically the same. The females appear to outnumber the males. Among 462 engorged nymphs the molting of which was recorded, 251 were females and 211 were males. Collections of unengorged ticks in nature also appear to indicate that the females outnumber the males.

## SEASONAL INCIDENCE AND OVERWINTERING

A knowledge of the seasonal incidence of adult ticks is of much importance in the epidemiology of Rocky Mountain spotted fever and the control of that disease. The seasonal incidence differs in different parts of the country. In general, the adults of this species are most abundant in the spring and early in the summer. In Maryland and adjacent States the ticks begin to appear from the middle of March to the middle of April, depending upon the temperature. They usually reach maximum abundance the latter part of May or early in June and decline sharply in numbers after mid-July. Relatively few ticks are seen after August 1. Appearance is usually slightly later farther north along the Atlantic coast.

The seasonal incidence of adults in northern California appears to be similar to that in Maryland. In Iowa their activity continues later in summer.

The seasonal abundance of adults in the Central States is illustrated by results of a survey conducted at Osceola, Iowa, in 1934 by George S. Cantonwine. Ticks were collected daily from a dog and from 10 cows which were kept in the same pasture throughout the study. The first collections were made on June 6, when between 20 and 30 ticks were removed from each animal. The period of greatest abundance was from June 6 to June 14, as many as 64 ticks attaching to a single cow in 1 day. Ticks were slightly less abundant from June 15 to June 29, and the period from June 30 to July 6 showed a further slight decrease. A great decrease in abundance was noted between July 7 and August 3, and ticks were completely absent from August 4 to August 12, when the temperature reached 115° and 120° F. When the temperature dropped to normal on August 13, ticks reappeared, but were less numerous than before, and were collected in constantly dwindling numbers until September 24, after which no ticks were found.

In the South the seasonal activity is not so sharply restricted. In fact adults have been taken on hosts in Florida and Texas every month of the year. As a rule, however, they are more abundant in spring. The hot, dry weather of midsummer practically stops activity.

In the Southern States there is continuous but retarded breeding throughout the winter. In the colder parts of the country over-wintering may take place in all stages except as eggs. As few females become engorged and lay eggs late in the summer, most egg masses hatch before winter sets in.

The adults, in the unfed state, seek protected places in the fall. They have been found in numbers completely quiescent deep down in clumps of bunch grass. When warmed they become active in a short time. Larvae and nymphs are to be found on mice and other small mammals throughout the winter. Groups of mice were collected in the District of Columbia and nearby Maryland and Virginia during the winter of 1933–34. Larvae and nymphs were found attached to 31 percent of these groups. During January as high as 102 larvae and nymphs were taken on a single meadow mouse. It was noted that the number of immature ticks on animals increased after periods of mild weather and was almost nil following severe weathers. It should be remembered that these mice remain active throughout the winter.

Since the development of larvae and nymphs toward molting progresses very little during cold weather and speeds up at higher temperatures, it appears that the ticks engorged during winter all molt during a comparatively short time in spring. This coincides with the finding in nature of large numbers of unfed adults and nymphs in spring, while seed ticks are relatively scarce.

## NATURAL CONTROL

*Hunterellus hookeri* Howard is the only tick parasite that has been taken on *Dermacentor variabilis.* It readily attacks and develops in nymphs of this species under laboratory conditions. In nature collections have been made on Naushon Island, Mass., and Capers Island, S. C., where the parasite had been liberated 1 or 2 years previously. The South Carolina collection consisted of a single nymph taken on a cow. It yielded six parasites. This parasite species was liberated by F. Larrouse on Cape Cod, Mass., and adjacent islands in 1929; and while it successfully overwintered there (7), it has not been recovered in collections of nymphs made during the last 3 years. The difficulty of controlling the American dog tick by artificial means makes desirable further work with this parasite.

Predators such as poultry, birds, and mice doubtless destroy many American dog ticks, particularly the engorged females.

Probably climatic factors are of most importance among the natural control agencies. Of these lack of moisture is dominant. Excessive dryness is very destructive to all stages. Probably this is the principal limiting factor in Western States. As previously indicated, desiccation greatly shortens the length of life of seed ticks, nymphs, and adults, and eggs fail to hatch under excessively dry conditions.

The American dog tick is very resistant to cold, as indicated by the fact that it is abundant in such Northern States as Massachusetts, Wisconsin, and Minnesota.

No appreciable mortality due to cold occurs among larvae, nymphs, or adults exposed during winter at Washington, D. C.

Unengorged larvae and nymphs were subjected to low temperatures in a refrigerator for periods of 24 to 72 hours. Temperatures above 0° F. did not kill any individuals, temperatures ranging from −1° to −9° killed some but not all of the larvae and nymphs exposed, while temperatures below −10° produced 100-percent mortality. Exposure to temperatures low enough to kill 75 percent of the nymphs in one lot did not affect the ability of the surviving 25 percent to attach and engorge.

Measurements of the undercooling and freezing points of females were made with a thermocouple and potentiometer. In the case of unengorged females the undercooling point ranged from 19.7° to 3.5° F., the average being 9.3°, and the freezing point ranged from 21.7° to 11.8°, the average being 16.2°. Among the engorged females the undercooling point ranged from 22.1° to 3.9°, with an average of 13.4°; the freezing point ranged from 25.1° to 16.8°, the average being 21.7°.

## ARTIFICIAL CONTROL

The control of a tick with such general host habits and with such longevity and wide distribution as the American dog tick is a difficult matter. In areas where there is an abundance of both small and large wild animals its complete control appears almost impossible, but further experimental work may indicate some practical method of greatly reducing its numbers.

In certain areas where the tick is abundant, large wild mammals that are suitable for the engorgement of adult ticks are few or absent. This is true on certain islands along the coast, as on Martha's Vineyard and Nantucket, Mass. Under such conditions the strict control or treatment of dogs, which are by far the most important host of the adults, so as to prevent the engorgement of adults would, it is believed, result in reasonably good control of the pest. This measure might well be coupled with campaigns against the meadow mice—the principal host of the immature stages.

The thorough application of derris as a powder or wash is effective in destroying the ticks already attached and in preventing the reinfestation of dogs for short periods. Application is easier when the powder is used, and ticks that actually come in contact with the derris will be killed, but the animals are less thoroughly covered than when the material is used as a wash or dip. In addition to giving a more complete treatment at the time of application, the derris applied as a wash is retained on the hair and skin longer than the powder and has a more extended repellent action. When used by either method, derris is more effective against flat or slightly engorged ticks than against the fully engorged females, so, in order to prevent all reproduction, treatments should be given before females become well engorged. The powder should be applied at intervals of 2 or 3 days and the wash or dip at intervals of 5 or 6 days. Such treatment will greatly reduce the number of ticks becoming attached, and prevent engorgement and reproduction.

The derris powder should have a rotenone content of at least 2 percent. An effective dip or wash can be made by dissolving an ounce of soap in a gallon of water and adding 2 to 4 ounces of derris powder of which the rotenone content is 4 percent.

Coal tar-creosote dip and the standard arsenical dip used to control cattle ticks are also useful in killing ticks on dogs, but from a few preliminary observations these materials do no appear to be as effective as derris.

If arsenical dip is used, care must be taken to keep the dogs on their feet until the dip dries, or burning may result.

Clearing away undergrowth and keeping grass cut closely, especially near habitations, camps, walks, etc., greatly reduces the chance of human infestation. The use of clothing calculated to exclude ticks, when one finds it necessary to traverse tick-infested areas, helps protect against attack. Watchfulness for ticks will usually result in their removal before they attach. Frequent examination of the body, and especially the head, is important so as to remove ticks before they have attached long.

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